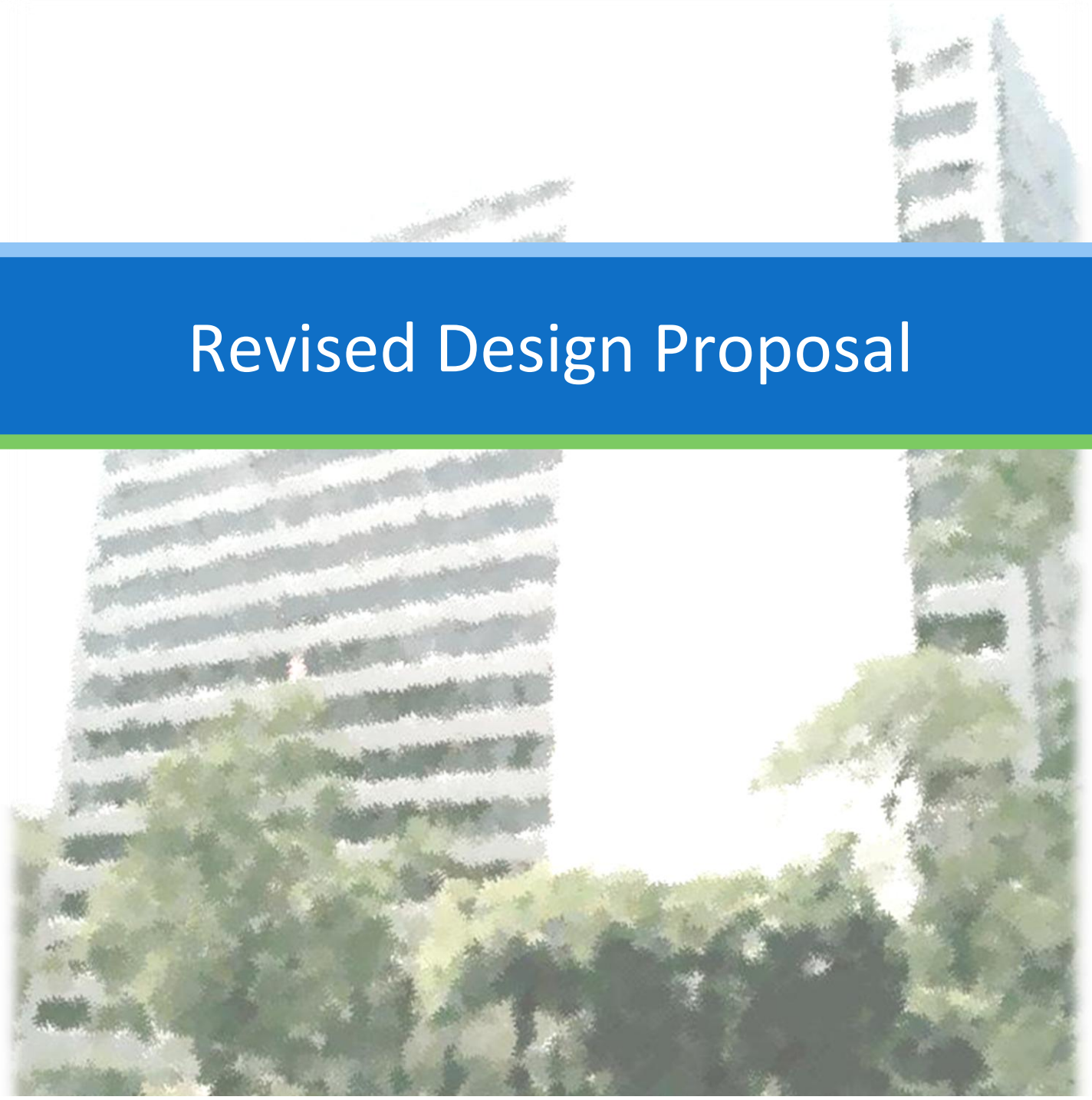
Revised Design Proposal



RIVER VUE APARTMENTS, PITTSBURGH, PA

January 13, 2012
Authored by: Laura C Pica
Adviser: Stephen Treado

Revised Design Proposal

River Vue Apartments, Pittsburgh, PA

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Executive Summary

A formal design proposal will serve as a guide and schedule to modify the current design of River Vue Apartments throughout the Spring 2012 semester. A large depth study will be conducted in the area of mechanical systems design while two breadth studies will focus on other areas of the Architectural Engineering program, such as lighting/electrical and construction management, to emphasize the importance of integrated design.

As noted in Technical Reports 1, 2, and 3, there are several aspects of the current design that do not meet current ventilation or energy standards and therefore prevent River Vue Apartments from being a leading building in energy performance. The building receives low amounts of ventilation air, uses highly repetitive heat pumps in each of the apartment units and suffers from high solar gains due to excessive glazing on the façade. Although the construction process will be highly organized and implement regional materials and recycling programs, River Vue Apartments barely achieves LEED Certified status and may contribute to the urban heat island effect.

In order to improve the building's energy usage, the building's current heat pumps will be removed to allow for re-zoning of the interior spaces. Demand control ventilation will be implemented using high velocity air streams and CO_2 sensors to monitor occupancy and regulate ventilation more accurately. The current make-up air handling unit will be resized to manage this system and small supply air ducts will be designed for central corridor distribution.

The first breadth study will examine the installation of a photovoltaic array for the roof and if the net electric consumption for the building can be reduced. These panels may improve the energy usage and sustainability points of River Vue apartments while allowing for internal shading devices to be implemented to reduce solar gains. Cost analysis and payback time will be studied to examine the benefit of this option.

A second breadth study will focus on the scheduling and cost impacts of changing the mechanical system and controls, as well as the addition of the photovoltaic array and corresponding electrical components. A bid package with material and equipment take-offs will be prepared and supplemented with a construction schedule.

NOTE: This study is an educational exercise in preparation for my career as a mechanical engineer at a design firm and as a project manager later in my career. All calculations and design proposals are solely my work and are not meant to be a replacement for the current project design.

Background Information

River Vue Apartments is a renovation project to turn the Old State Office Building located downtown Pittsburgh, Pennsylvania into a high rise multifamily apartment complex. The site is tightly constrained by neighboring buildings and historic sites. Most of the existing structure will remain with the exception of fenestration which will be replaced to lighten the solar gains and the addition of interior cross bracing in the basement and ground floor levels.

Ventilation is provided by the single make up air handling unit and operable windows whereas heating and cooling is supplied by heat pumps located in each apartment unit. Loop water serves the heat pumps and a chilled water loop provides water for domestic use. Minimal floor space is lost on each floor due to mechanical equipment and shafts.

Construction spans over a time period of approximately ten months and involves the demolition of all existing interior work, installation of new mechanical, electrical and plumbing systems as well as new finishes, site work, and balconies for units on upper floors. The guaranteed maximum price of $28 million allows little room for energy modeling or energy usage tracking however, LEED Certified status will be achieved through the use of regional and recycled materials, reuse of the project site and detailed management and commissioning of the project from construction through project delivery.

Existing Conditions

Technical Reports 1, 2, and 3 were used to examine the existing conditions of the building's structure, mechanical and electrical systems design and expected operation, annual energy usage, cost of operation and sustainability. Research has concluded that the following areas are of concern and should be considered for redesign:

- Insufficient ventilation supply air in many internal spaces (as compared to ASHRAE specifications)
- High solar loads from excessive fenestration
- No occupancy sensors for ventilation control
- No energy storage
- Low thermal mass in structure
- Building contributes to urban heat island effect

In a complex like River Vue Apartments where utility costs are directly transferred to the tenants, efficient use of energy is of high concern, especially during the middle of summer and winter months when cooling and heating loads are at their peak. The current high monthly energy bills combined with low indoor air quality and thermal comfort make for an unattractive housing option and therefore require design alternatives.

With today's concerns about national energy supply and economics, many consumers are also shopping for apartment communities that are taking responsibility for their energy usage and making a conscious, public effort to implement new technologies and cut back. If River Vue Apartments can successfully do so, it will be a leader in the community and attract even more future tenants.

In addition to the tenants, the building owner and operator must feel comfortable renting out the facility. The apartment complex should have low maintenance requirements and easy operation so that it can be an economical property with which he or she can profit in the long term.

Depth Design Alternatives

Understanding all of the current design issues as well as tenant and owner concerns lead to the development of several alternatives for the redesign of the mechanical system's components as follows:

Demand Control Ventilation

High velocity air can be provided from the make-up air handling unit while occupancy sensors regulate the amount of ventilation provided. This scheme will require the rezoning of interior spaces and resizing or replacement of the existing AHU. CO_2 occupancy sensors will be integrated into the new control system for accurate ventilation at all times.

Absorption Chiller

The addition of an absorption chiller could be used to produce thermal storage in the form of ice. High boiler water temperature is necessary to produce water hot enough to have excess heat for absorption however; if solar collectors are used thermal storage could be supplemented. Additional structural support will likely be necessary due to the added weight of the equipment.

Radiant Slabs with DOAS

Radiant slabs will provide sensible heating or cooling for the building's zones while a dedicated outdoor air system would supply necessary ventilation air. This scheme would require changes to the current water loop and control systems and structural systems depending where the radiant slabs are located and what size is required.

Geothermal Loop

A closed geothermal loop, connected to a heat pump at both ends, can be inserted into a long well in the site surrounding River Vue Apartments to take advantage of constant ground temperatures. The loop would have to be in one of two forms, either the form of a single deep well on site or a remote coiled loop in one of the three nearby rivers since there is extremely limited space on the project site itself. This option seems least likely to be developed since deep well digging would be difficult on site and access to the river water is confined due to neighboring buildings, streets, and the historical Point State Park.

***Note**: Although only one design alternative was chosen for the purpose of this proposal, it may become evident through further research that additional design alternatives are necessary. Therefore, the list above will remain in full consideration until further study can be conducted.*

Proposed Depth Redesign

Applying a demand control ventilation system with high velocity air supply and CO_2 occupancy sensors for added control will provide the potential to save supply fan energy while improving indoor air quality and reducing operating costs. There is little room for additional ductwork in the existing ceiling plenum therefore a single central-hallway distribution will be implemented. An analysis of the payback period will be influential in determining if this redesign is cost-effective.

It is expected that the current make up air handling unit will be resized significantly in this redesign process because the heat capacity of air is far less than that of water. Initial construction cost will shift with the purchase of a larger air handling unit, ductwork and sophisticated controls but hundreds of heat pumps and piping fittings are to be deleted.

Changes to the mechanical system's make up air unit will undoubtedly affect the building's structural and electrical systems because with increased equipment size comes increased dead load on structural joists and columns and increased electrical feeder sizes. The construction schedule will also be affected since individual heat pumps will not be installed but rather ductwork will be navigated through each floor's central corridor. The façade will remain intact but as noted in Technical Report 1, there is significant heat gain from excessive fenestration which contributes to high cooling loads in summer months and high heating loads in winter months.

The payoffs will be improved indoor air quality with increased ventilation to meet ASHRAE specifications, zone control with occupancy sensors, and increased rental space in each apartment unit with the subtraction of individual heat pump mechanical space. Less maintenance is expected with one large system rather than individual units and therefore operational costs may decrease as well.

It is important to note that this redesign process is also an educational experience and will provide insight into mechanical system design for high-rise apartment facilities.

Tasks

1. Research DCV System & CO2 Sensors
2. Adjust size of make-up air unit (or replace)
3. Compare energy recovery options for AHU
4. Select CO2 occupancy sensors for building and assign locations for placement
5. Size new ductwork and diffusers based on ASHRAE Standard 62.1
6. Layout new ductwork and diffusers
7. Complete energy and cost analyses for AHU design options
8. Create summary report

Tools

Some or all of the following design guides, reference manuals, and software programs may be used in the design of the Demand Controlled Ventilation system:

- Demand Control Design Guide by Carrier
- Demand Control Design Guide produced by the Oregon Office of Energy
- ASHRAE Standards 62.1 and 90.1
- ASHRAE Book of Fundamentals
- Trane TRACE

Proposed Breadth 1

An electrical investigation will consider implementing a photovoltaic array on the roof of the building to improve net electric consumption and achieve further sustainability points for River Vue Apartment's LEED Score. The electricity generated from the array can supplement the needs of the building to reduce the total annual demand and potentially power internal shading devices that can shield the building from high solar gains.

In order to assess this option, calculations will be necessary to determine the most effective angle to receive solar radiation, the area of the array that will provide sufficient electric output, electric feeder sizing, and the weight of the array and its effect on the existing structural system. As with any addition, economics are a major factor in the consideration of a design and therefore the initial cost and payback period will be analyzed. The expected electric output will be considered to understand what portion of the building's energy consumption it can replace and if this option will yield a positive return on investment.

Tasks

1. Research photovoltaic systems
2. Calculations, panel sizing
3. Layout array
4. Size corresponding wiring, panel board, etc.
5. Investigate payback period & economics
6. Research internal shading devices
7. Create summary

Tools

Some or all of the following design guides, reference manuals, and software programs may be used in the design of the photovoltaic array system:

- AE 456 & AE 467 lecture materials and course text books
- Building Integrated Photovoltaic Designs for Commercial and Institutional Structures: A Sourcebook for Architects
- National Electric Code 2008
- AutoCAD 2011

Proposed Breadth 2

Since I have a professional interest in becoming a project manager for a mechanical contractor later in my career, a construction management study consisting of a cost estimate, schedule changes and the sustainability impact of adding demand control ventilation and a photovoltaic array would be beneficial. A brief bid package for the addition of the new mechanical equipment and material will be produced and compared to the original design cost data provided by Turner project management.

Tasks

1. Equipment and material takeoff
2. Equipment and material pricing
3. Create bid package
4. Estimate delivery, installation, and start-up times& develop new project schedule
5. Create Summary

Tools

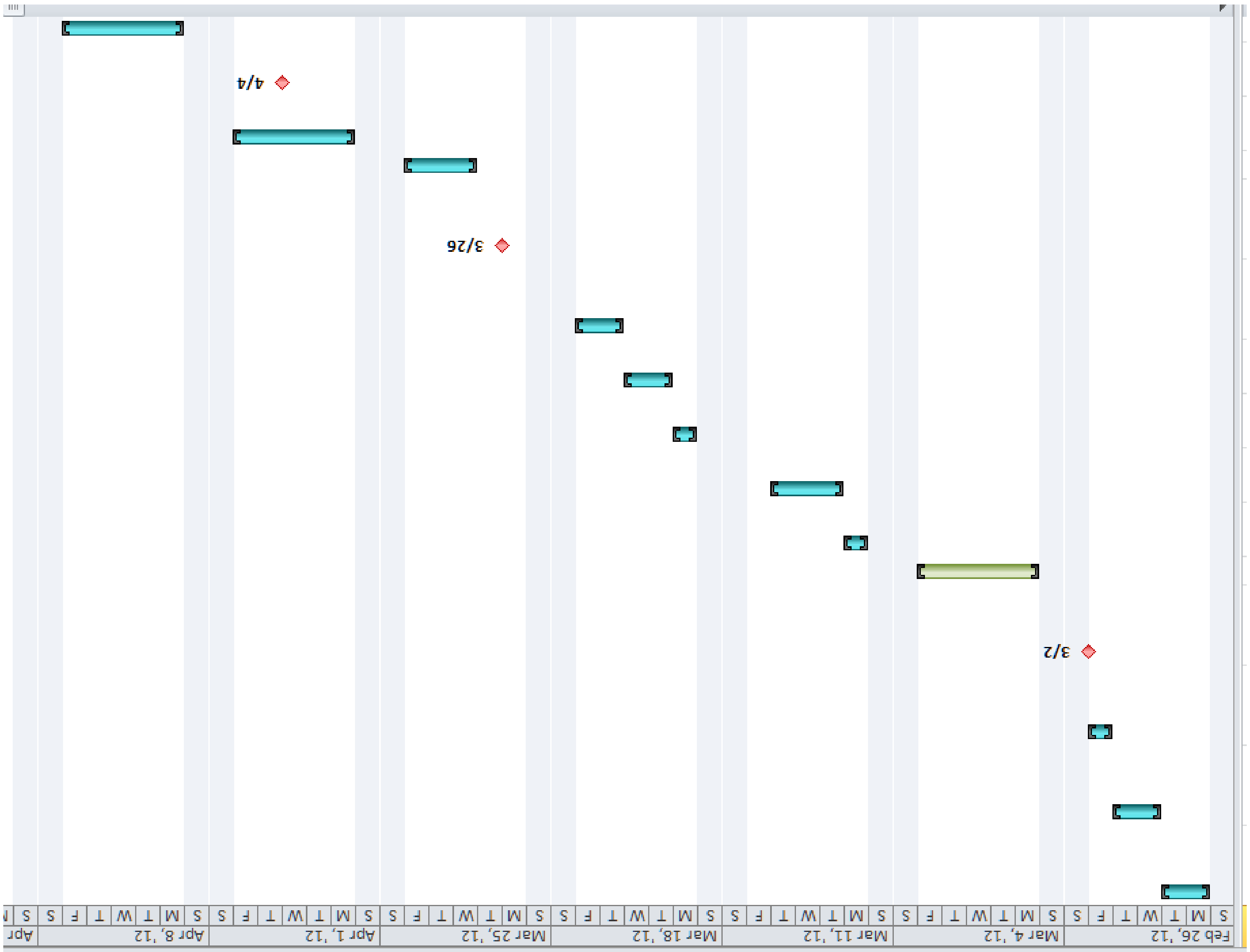
- R.S. Means Catalogs
- Equipment manufacturer catalogs
- Microsoft Excel
- Microsoft Project

List of Tasks

Task Name	Duration	Start	Finish
Semester Begins	1 day	Mon 1/9/12	Mon 1/9/12
Revise Proposal	5 days	Mon 1/9/12	Fri 1/13/12
Depth Task 1 - Research DCV	2 days	Wed 1/11/12	Thu 1/12/12
Depth Task 1 - Research CO2 Sensors	2 days	Thu 1/12/12	Fri 1/13/12
Depth Task 2 - Rezone Spaces	1 day	Mon 1/16/12	Mon 1/16/12
Depth Task 3 - Adjust AHU	3 days	Mon 1/16/12	Wed 1/18/12
ASHRAE Winter Conference	5 days	Sat 1/21/12	Thu 1/26/12
Depth Task 4 - Select CO2 Sensors	2 days	Thu 1/26/12	Fri 1/27/12
Milestone 1 - Revised Proposal Posted	1 day	Fri 1/27/12	Fri 1/27/12
Depth Task 5 - Size new ductwork, diffusers	5 days	Mon 1/30/12	Fri 2/3/12
Depth Task 6 - Layout new duct	5 days	Mon 1/30/12	Fri 2/3/12
Assemble Depth Report	3 days	Mon 2/6/12	Wed 2/8/12
Breadth 1 - Task 1 - Research PV Systems	2 days	Thu 2/9/12	Fri 2/10/12
My Birthday	1 day	Sun 2/12/12	Sun 2/12/12
Milestone 2 - Completion of Depth Study 1	1 day	Mon 2/13/12	Mon 2/13/12
Breadth 1 - Task 2 - Select Panels & Sizing	3 days	Wed 2/15/12	Fri 2/17/12

Breadth 1 - Task 3 - Layout Array	1 day	Mon 2/20/12	Mon 2/20/12
Breadth 1 - Task 4 - Size Corresponding Electrical Components	2 days	Wed 2/22/12	Thu 2/23/12
Breadth 1 - Task 5 - Investigate Payback Period	2 days	Mon 2/27/12	Tue 2/28/12
Breadth 1 - Task 6 - Research Internal Shading Devices	2 days	Wed 2/29/12	Thu 3/1/12
Breadth 1 - Task 7 - Write Breadth 1 Summary	1 day	Fri 3/2/12	Fri 3/2/12
Milestone 3 - Completion of Breadth Study 1	1 day	Fri 3/2/12	Fri 3/2/12
Spring Break	5 days	Mon 3/5/12	Fri 3/9/12
Breadth 2 - Task 1 - Takeoffs	1 day	Mon 3/12/12	Mon 3/12/12
Breadth 2 - Task 2 - Pricing	3 days	Tue 3/13/12	Thu 3/15/12
Breadth 2 - Task 3 - Develop Bid Package	1 day	Mon 3/19/12	Mon 3/19/12
Breadth 2 - Task 4 - Schedule Changes	2 days	Tue 3/20/12	Wed 3/21/12
Breadth 2 - Task 5 - Create Breadth 2 Summary	2 days	Thu 3/22/12	Fri 3/23/12
Milestone 4 - Completion of Breadth Study 2	1 day	Mon 3/26/12	Mon 3/26/12
Assemble Final Paper	3 days	Wed 3/28/12	Fri 3/30/12
Assemble Final Presentation	5 days	Mon 4/2/12	Fri 4/6/12
Milestone 5 - Final Report Due	1 day	Wed 4/4/12	Wed 4/4/12
Final Presentations	5 days	Mon 4/9/12	Fri 4/13/12
ABET Evaluations	1 day	Mon 4/16/12	Mon 4/16/12
CPEP Finalizations	2 days	Thu 4/19/12	Fri 4/20/12
Semester Ends & Senior Banquet	1 day	Fri 4/27/12	Fri 4/27/12
Graduation	1 day	Fri 5/4/12	Fri 5/4/12

Gantt Chart Schedule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Apr 8, '12
Apr
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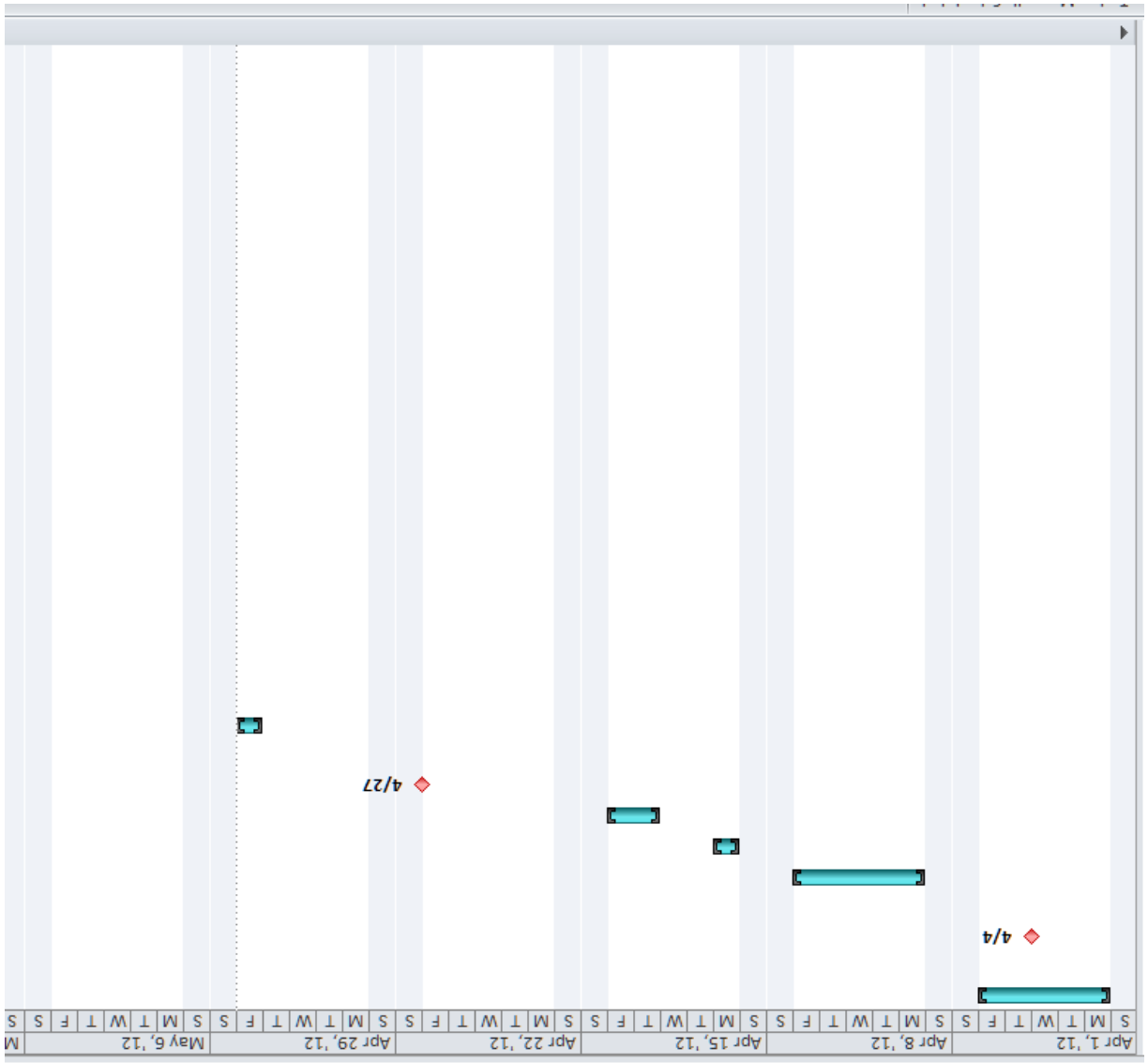
3/26
4/4


Apr 1, '12
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Apr 15, '12
Apr 22, '12
Apr 29, '12
May 6, '12
4/4
4/27

Preliminary Research Bibliography

Design advice and recommendations for Demand Control Ventilation systems was found from the following sources:

1. Holmberg, David. (November 2011). Demand Response and Standards. *ASHRAE Journal*, pages B23-B35.
2. John, David. (September 2011). Designing for Comfort. *ASHRAE Journal*, pages 38-47.
3. Shapiro, Ian. (October 2011). HVAC Selection for Envelope-Dominated Buildings. *ASHRAE Journal*, pages 30-40.
4. Stipe, Marty. (2003) Demand-Control Ventilation Design Guide. *Oregon Office of Energy*. http://www.oregon.gov/ENERGY/CONS/BUS/DCV/docs/DCVGuide.pdf?ga=t
5. Turner, Stephen. (June 2011). What's New in ASHRAE's Standard on Comfort. *ASHRAE Journal*, pages 42-48.

Geothermal loop systems for underground use were researched from the following source:

1. Geothermal Loops – Geothermal Loopfields. Eagle Mountain Products. Accessed December 5, 2011. http://www.eagle-mt.com/geomax/geothermal_loops.php

Absorption Chillers and their corresponding mechanical systems were researched using the following:

1. McQuiston, Parker & Spitler. (2005). Heating, Ventilating, and Air Conditioning Analysis and Design. Sixth Edition.
2. Wang, Kai and Vineyard, Edward. (September 2011). Absorption Refrigeration. *ASHRAE Journal*, pages 14-24.

Photovoltaic arrays and solar thermal technology was researched using the following:

1. Beckman, Duffie. (2006). Solar Engineering of Thermal Processes, Third Edition.
2. Bushby, Steven. (November 2011). Information Model Standard for Integrating Facilities with Smart Grid. *ASHRAE Journal*, pages B18-B22.
3. Newell, Ty and Newell, Ben. (June 2011). Solar Collection and Use. *ASHRAE Journal*, pages 72-77.

Concluding Remarks

This proposal should be considered a work-in-progress as the tasks and schedule for each study outlined are subject to change as further research is completed. The goal of each design proposal is to conserve net energy usage, improve sustainability, reduce building emissions, and promote integrated design techniques. Architectural engineering is about considering all possibilities and merging the best design strategies to create an efficient, beautiful product.

Acknowledgements

Thank you to the following people for your help and support:

- My adviser, Stephen Treado, for his help in editing my technical reports and providing professional consulting
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